Ridged Waveguide Bandpass Filter for Terahertz Applications

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Abstract – **In this paper a CAD procedure for the design of ridged waveguide E-plane filters for THz applications is presented. The transverse resonance technique has been applied for the rigorous analysis of modal propagation in ridged waveguide. Mode matching method has then been used to derive scattering parameters for the discontinuities involved in a ridged waveguide filter. In order to exhibit the performance of the developed CAD, three bandpass filters at 0.270, 0.550 and 1.340 THz have been designed, simulated and presented.**

I. Introduction

The cross-sectional shape of the ridge waveguide is shown in Fig. 1. Firstly proposed in [1], ridge waveguide propagation has been rigorously studied in [2], [3] and is well known to combine the advantages of lower cutoff frequency of the dominant mode, wider bandwidth free from higher modes and low characteristic impedance. Furthermore, the guided wavelength as well as the characteristic impedance in ridged waveguide propagation varies with the ridges height. Therefore, with no particular constructing difficulty, this type of waveguide permits altered propagation characteristics.

Due to these properties, it is believed that the use of sections of ridged waveguide as resonators in an all-metal E-plane filter may optimize its performance in terms of second passband attenuation; all the waveguide sections will be resonant at a single fundamental frequency, but not simoultaneously resonant at any higher frequencies, due to different guide wavelengths in the different filter sections [4]. In order to analyze the proposed filter (Fig. 2), a rigorous analysis of the ridged waveguide propagation is necessary, that can calculate the cutoff frequency as well as the field distribution of each mode. Mode-matching technique will then be applied in order to study the ridged waveguide to metal insert discontinuity.

The generalized transverse resonance method, as described in [3] is appropriate for such demands.

II. THEORY

The analysis of the electromagnetic propagation in a ridged waveguide is based on the generalized transverse resonance technique and implementation of field matching. Since the cross-sectional distribution of the field is independent of the frequency [5], we may analyse the field distribution for a waveguide mode at its cutoff frequency, assuming standing waves along the transverse coordinates and no propagation along the longitudinal axis (transverse resonance). The concept of field matching lies into theoretical division of the cross section under consideration into discrete regions where it will be easy to formulate the x- and y-dependence of the fields. The interface relation (continuity of tangential fields) is then applied. Due to the x-symmetry of the structure, the analysis can be carried out assuming only half of the structure's cross-section. In order to account for all possible cases, along the symmetry plane we should consider both an electric and a magnetic wall [2]. Odd modes however have been proven to be sufficient for the characterisation of the discontinuities under consideration[3].

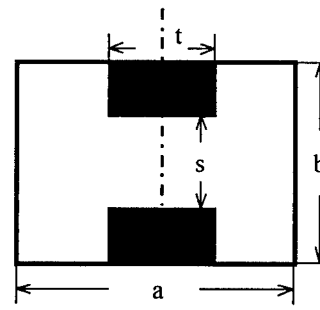

Fig. 1: Cross-section of a ridged waveguide

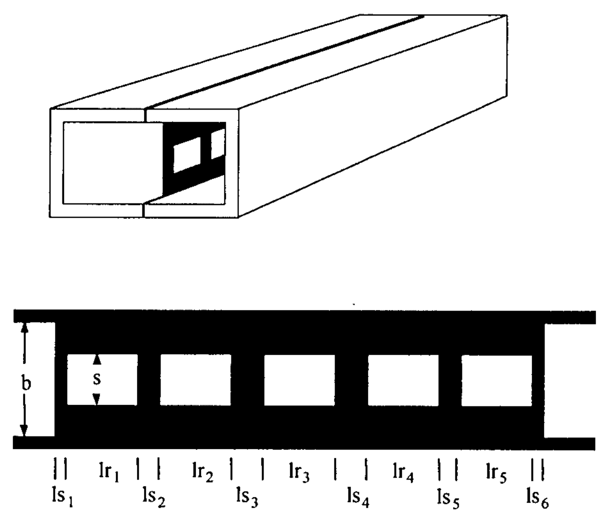

Fig. 2: Ridged waveguide bandpass filter

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Mode Matching Method makes use of the orthogonality of the modal solution of the field distribution.
Tangential fields, expressed in terms of vector potentials [5] are matched in their common surface and using the orthogonality properties, the generalised scattering matrix can be obtained. Even though transmission matrix representation will lead to an easier formulation for the characterisation of cascaded discontinuities, this procedure is potentially unstable due to exponentials with positive arguments. Therefore the scattering matrix representation is used throughout [7].

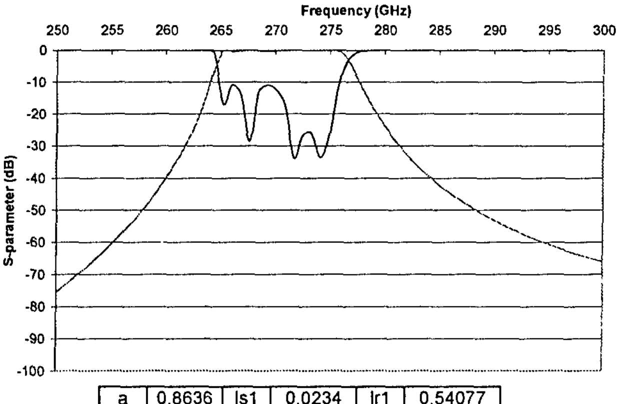
The design procedure is based on the method proposed by Rhodes [4, 8]. Once the prototpye filter has been chosen, the equivalent K-inverter representation with half waveguide wavelength resonators is easily obtained according to [9]. Using the expressions given by Levy [10], the equivalent K value for each septum discontinuity can be obtained from its scattering matrix. Hence the lengths of the metal septa are determined. The resonator lengths are then calculated as half the guide wavelength adding or subtracting the necessary electrical length in order to ensure the K-inverter behaviour of the septa [10].

III. RESULTS

In order to demonstrate the performance of the presented CAD, three ridged waveguide filters have been designed. 20 TE and 20 TM modes were used for the design of each one, which lasted less than one minute on a Pentium Pro with 96MB RAM.

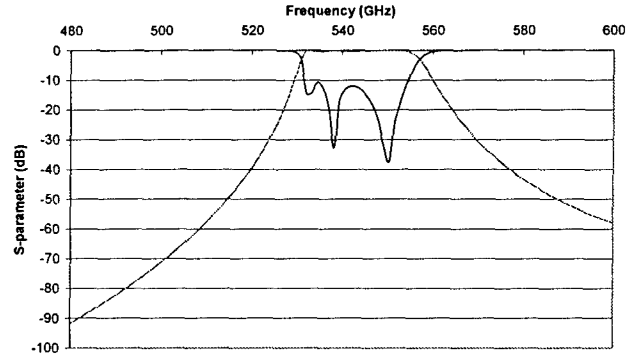
IV. CONCLUSION

An efficient CAD procedure for the design of ridged waveguide filters for THz applications has been presented. The efficiency of the procedure has been exhibited by designing three filters at 270, 550 and 1340 GHz.

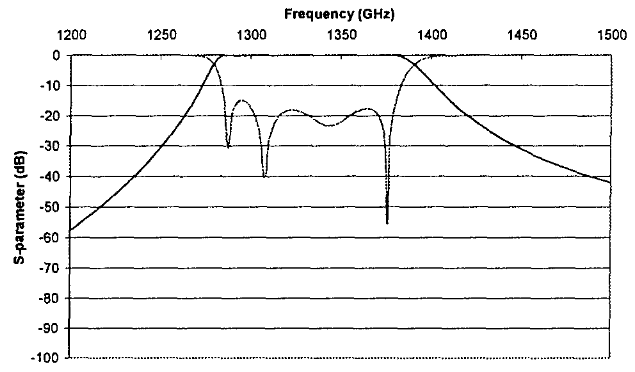


a	0.8636	ls1	0.0234	lr1	0.54077
b	0.4318	ls2	0.2211	lr2	0.550259
t	0.05	ls3	0.26875	Lr3	0.549771
s	0.2				

Fig. 3: Dimensions and performance of 270GHz bandpass filter



a	0.4	ls1	0.01	lr1	0.2655
b	0.399	ls2	0.0951	lr2	0.275
t	0.005	ls3	0.121	lr2	0.275
s	0.07				



a	0.15	ls1	0.0014	lr1	0.11
b	0.07	ls2	0.0185	lr2	0.1219
t	0.001	ls3	0.0250	lr2	0.1219
s	0.03				

Fig. 4: Dimensions and performance of 550 and 1340 GHz ridged waveguide bandpass filters

Acknowledgement

This work was supported by the Engineering and Physical Sciences Research Council by means of a research grant (GR/K58634), UK

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